CBRN Air Purifying Respirator Performance Testing

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CBRN APR
Scope of Presentation

- **The need to have performance based standards**
- **Review performance issues that have been raised regarding electrostatic filter media**

CBRN APR Equipment Standards Understanding Performance & Use

- Balance protection against expected use, workload and wearability
- Performance Tests need to represent the expected intended use conditions
- Need Performance based standard without Design Constraints
  - Design specifications prevent new technologies and next generation of designs
  - New technologies can increase the protection while increasing use and wear time (easy breathing, smaller, lighter weight products)

Current State: CBRN Respiratory Protection Performance Standards/Guidelines

- Joint Service General Purpose Mask (JSGPM)
- Joint Service Aircrew Mask (JSAM)
- C2A1 Canister
- SBCCOM Guidelines for Escape Hoods

Joint Service General Purpose Mask (JSGPM) & JSAM Performance Parameters

- **JSGPM Scope:** System will provide 24 hours continuous head-eye-respiratory protection Chemical, Biological, Radiological Particulates and TIM protection (rev: DAAD13-98-R-0045)
- **JSAM Scope:** Respirator for individual aircrew "above the neck" head, eye, respiratory and protection against chemical, biological warfare agents, radiological particles and toxic industrial materials, as wells as continuous protection against CB agent permeation through respiratory material (rev: 2 April 1999)

JSGPM & JSAM Performance Requirements: Examples

- Weight, Bulk, Vision, Communication
- Wearability: wear time, comfort, airflow resistance
- Interface criteria: optical, communication
- Long term aging
- Chemical Warfare Agents
  - Challenge, flow, RH, End Point, time
- TIMS
  - Challenge, flow, RH, End Point, time
- Biological & Radioactive Particles
  - DOP loading, Particle size, minimum efficiency

Performance Specification Canister, Chemical – Biological Mask C2A1: MIL-PRF-51560A(EA) 2 July 1997

- Document that describes the performance requirements of the C2A1
- Scope: Covers mask canister used to protect against chemical agents, biological agents and radioactive dusts.
- Performance based: airflow resistance, aerosol filtration, liquid agent permeation, gas service life, rough handling, accelerating aging, etc…

US Army Soldier Biological Chemical Command Guidelines/Performance Criteria Escape Hoods

- Guideline containing performance criteria and test methods for qualifying efficacy of hood-type RPE designed for self-rescue from CB incidents
- Performance Based
  - Chemical,TIMS, Particulate Filter Efficiency
  - Vision
  - Communications
  - Storage
  - Etc…

rev: 17, July 2000

Mandating Material/Design Specifications

What are the Issues?

- Specifying materials or how a system should achieve the desired outcome inhibits new technologies and product advancements.
- Examples:
  - Specifying one type of carbon for the canister
  - Specifying fiberglass filter media or mechanical filtration for the particulate filter

Filtration Criteria for CBRN APR Standard

- Needs to be performance based not material or mechanism based

Why is performance based in question?

- Performance of silicone
- Some reported concerns on filtration media
  - performance of electrostatic filter media against oil mists and solvents

Performance Requirements for Particulate Filtration: Oil Challenge

- 42CFR84 **"P-series"** test requires 200 mg DOP challenge (85 lpm, 0.185 micron particle size). Filter efficiency should be increasing at 200 mg load.
- **Overestimate** of workplace environments known to contain **oil aerosols, but a conservative approach**.
- Subsequent research supports the **P-series test as a relevant performance test**.

Performance Requirements for Particulate Filtration: Oil Challenge

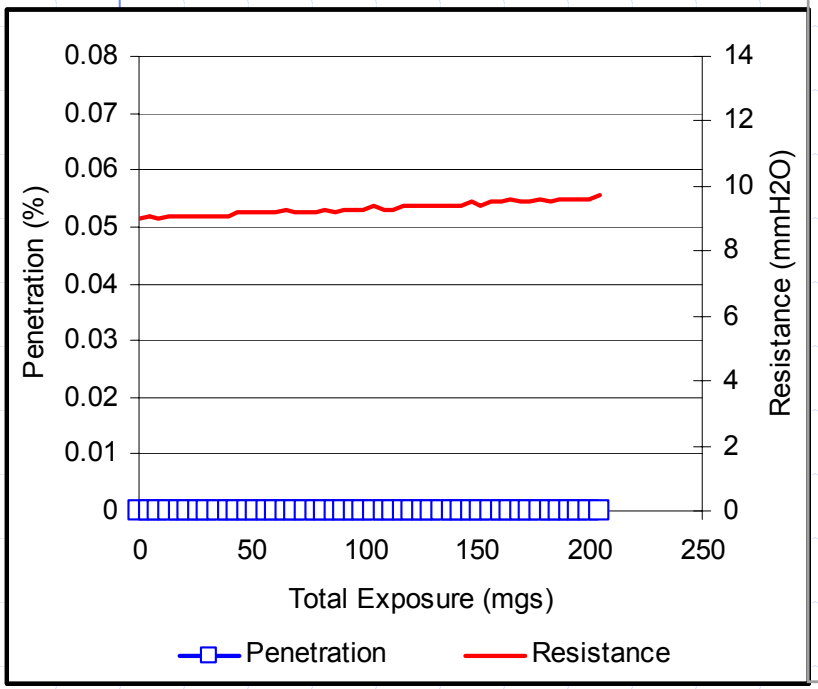
Example - Metal Working Fluids[1]:

1. NIOSH estimate of mean level of exposure in workplace is 1 mg/m^3 [2]
2. At moderate work rate, worker breaths 10-20 m3 per 8 hr day depositing 10-20 mg of oil on the filter
3. 40 hrs of use at these conditions equates to 50-100 mg loading, much less than the 200 mg test requirement
4. Tests on 3M P-95 respirator validated that the respirator is still greater than 95% efficient after 200 mg loading with metal working fluid (0.154 micron particles).

1. "Performance of R and P Series Particulate Respirators with Electret Filter Media against DOP, Paraffin Oil and Metalworking Fluids", Rousseau, Jones, Viner, Mullins, Cadalbert, 3M Company, OH&ES Division. Presented atAIHCE 1999. Submitted to AIHA Journal.
2. NIOSH: "Criteria for a Recommended Standard, Occupational Exposure to Metalworking Fluids" [DHHS (NIOSH Pub. No. 98-102]. Cincinnati, OH: NIIOSH, 1998

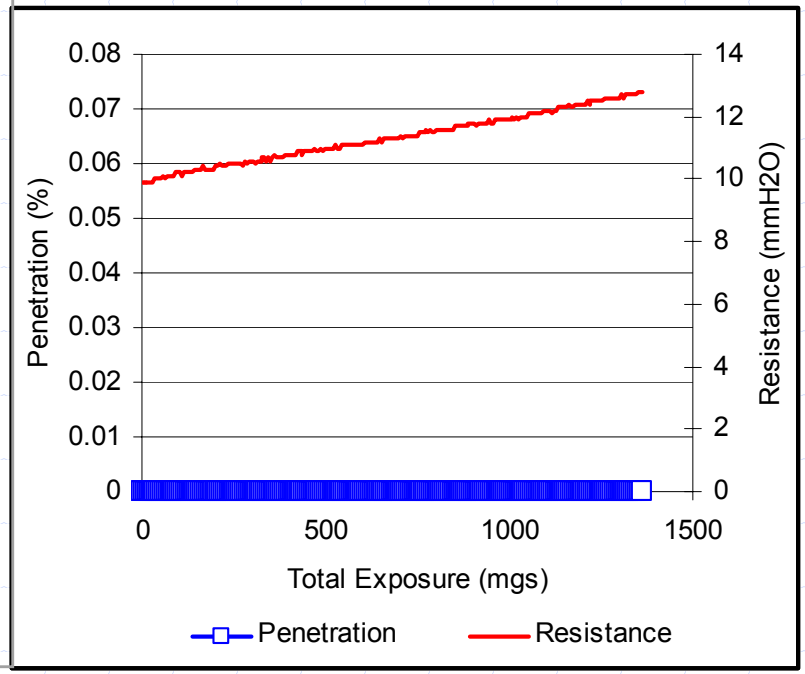
Particulate Filter Media Designed for Demanding Performance Application Example of 3M Electret

Milpro 830 Aerosol at 50 LPM
200 Milligram Loading Characteristics



7 Days Room Aging between Milpro and DOP Loading

DOP Aerosol at 50 LPM
1360 Milligram Loading Characteristics



Performance Requirements: Solvent Challenge

NIOSH Report at 2002 AIHC&E

- Exposed N,P Electrostatic filter media to saturation levels of IPA, ethyl acetate, acetone and pentane for varying times
- NIOSH Stated Conclusion: "This research shows that electrostatic respirator filters can be degraded by these organic vapors at saturation levels. However this degradation is not a concern because workplace concentrations will be much lower than saturation".

The Effects of Organic Vapors on the Efficiency of Electrostatic Respirator Filter Media Presented at 2002 AIHC&E, S.B. Martin, T.C. Wigal, E.S. Moyer

NIOSH Report at 2002 AIHC&E

Does Experimental Design Match Anticipated System Use?

Challenge	IDLH (ppm) (NIOSH PG)	~ saturation @ 23c (ppm)	3M 6001 Service Life (min)
IPA	2000	53,000	2
Ethyl Acetate	2000	111,000	1
Acetone	2500	280,000	0.5
N-pentane	1500	625,000	~ 0

Experiment found a failure point, but drawing conclusions has to be done with caution

Performance Requirements: Solvent Challenge 3M Report at 2001 AIHC&E

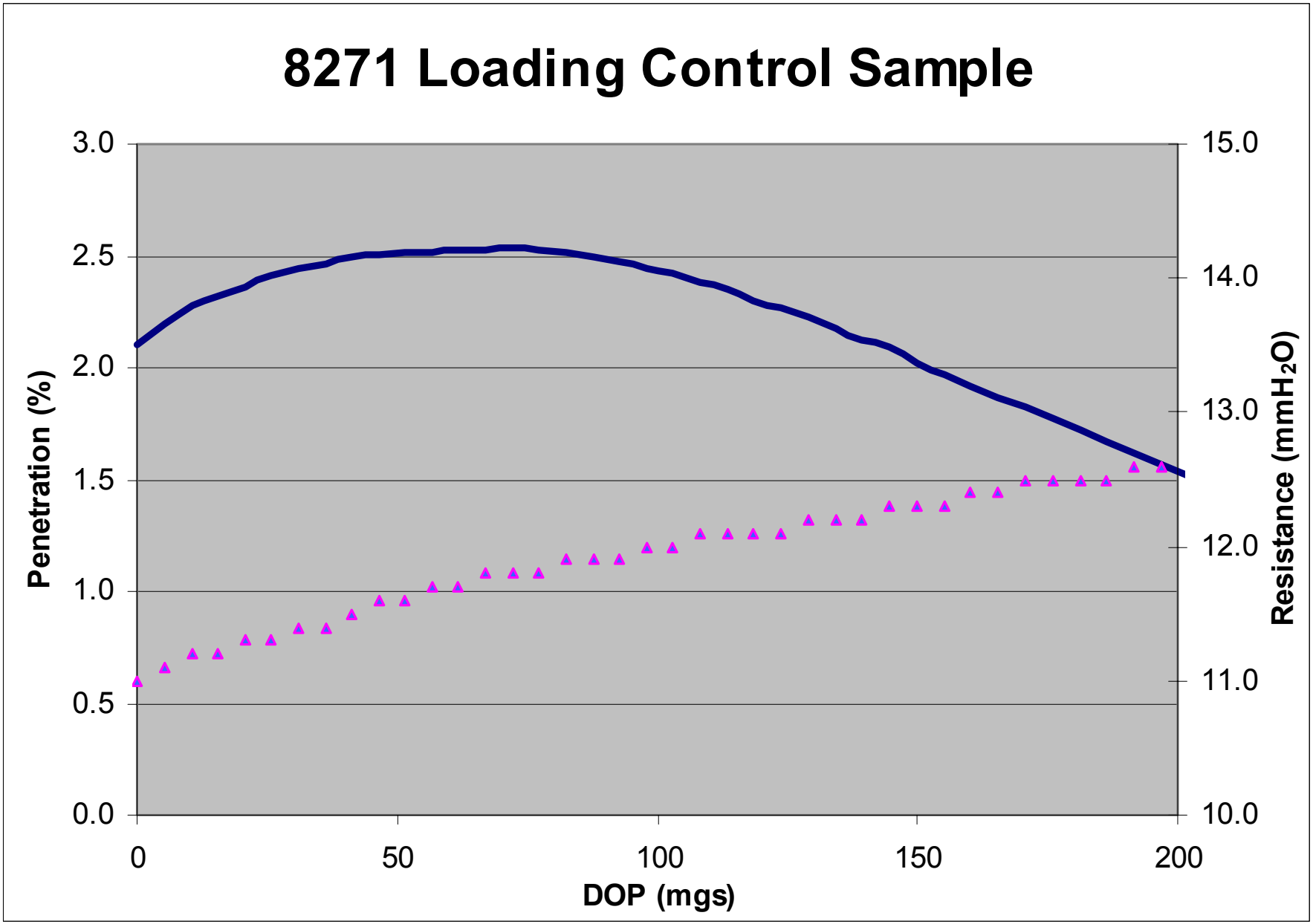
- 3M™ 8210 N95, 3M™ 8271 P95: Electret filter media from melt blown polypropylene fibers

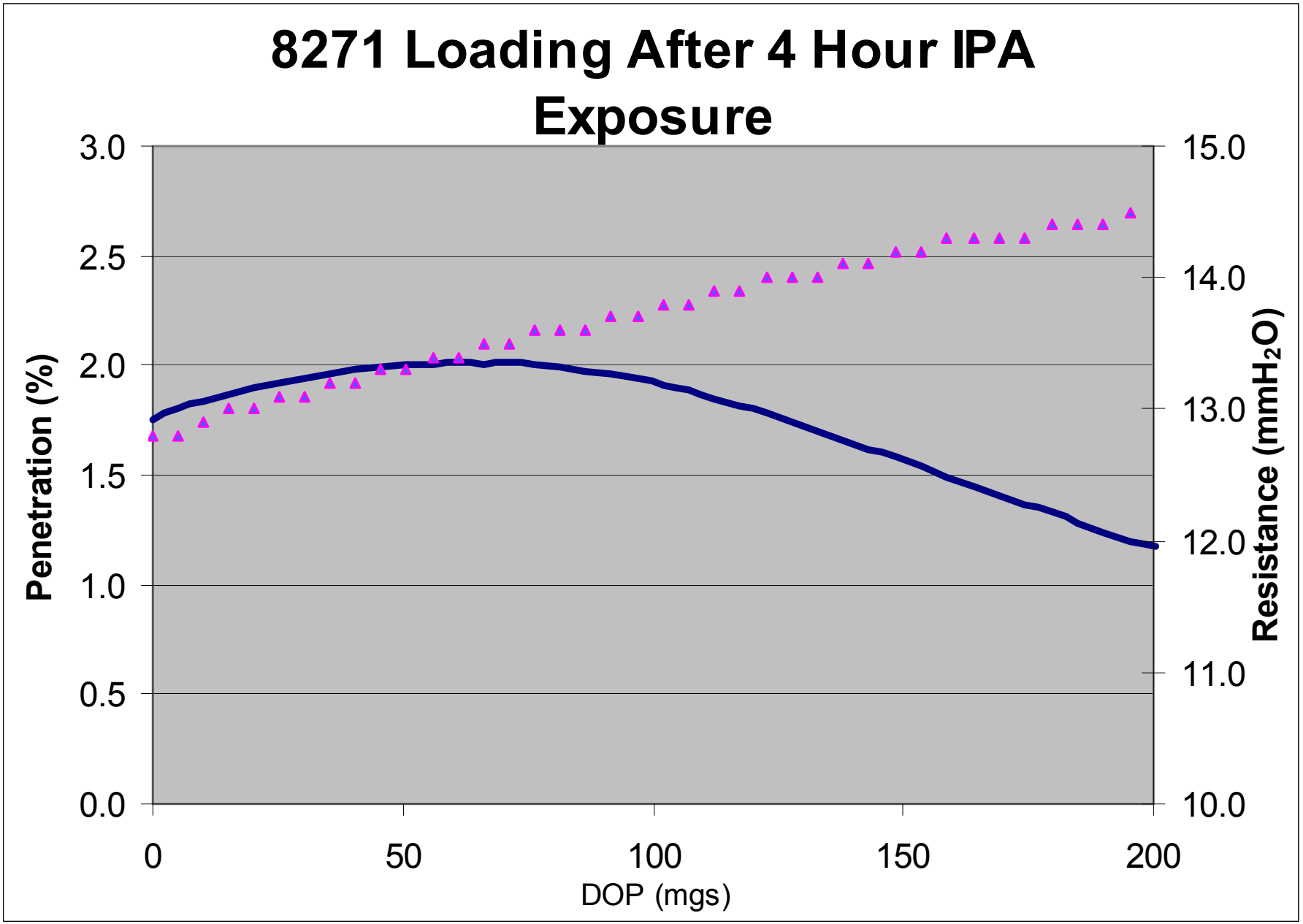
Test Protocol

- Solvents (OSHA PEL)
  - MEK (200 ppm)
  - Toluene (200 ppm)
  - Cyclohexane (300 ppm)
  - Isopropyl Alcohol (400 ppm)
- Exposure:10X PEL for 4 hours @ 32 LPM

  (example IPA: 4000ppm)

Performance of Respirators Made from Electrostatic Media
Reported at 2001 AIHC&E, A.D. Rousseau, M.E. Jones, JA. Eyberg, H.V. Hua, H.E. Mullins


8271 Loading Control Sample
Penetration (%)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Resistance (mmH2O)
15.0
14.0
13.0
12.0
11.0
10.0
0
50
100
150
200
DOP (mgs)


8271 Loading After 4 Hour IPA Exposure
Penetration (%)
Resistance (mmH2O)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
15.0
14.0
13.0
12.0
11.0
10.0
0
50
100
150
200
DOP (mgs)

Summary on Oil & Solvent Issues

- **OIL Challenge**
  - Current NIOSH Std is a relevant performance test for addressing oil and subsequent research supports the P-series test as a relevant performance test.
- **Solvent Challenge**
  - Two studies reported at different challenges – different outcomes.
  - If concerns exist - need to develop a test method to identify the desired performance under relevant conditions.
  - Test method must represent real world use and take into account the performance of the entire system.

Summary

- Need Performance based standard without Design Constraints
  - Disservice to the user to specify material or operating mechanism
  - Design specifications prevent new technologies and next generation of designs
- Protection relies on overall system performance
  - components, fit and wear time
- Need to consider the system when challenging filters, facepiece and other components to test methods.
- Manufacturers have extensive knowledge and expertise and we urge NIOSH to tap into it.